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Workshop on Secure Networks of Quantum Sensors

Proceedings

11-13 February 2026

Lip6, Sorbonne Université, Paris

Secure Networks of Quantum Sensors 2026			
Start time	Wednesday 11th February	Thursday 12th February	Friday 13th February
09:30	Coffee & discussion	Coffee & discussion	Coffee & discussion
10:00	Welcome & Overview	**Marco Barbieri** *Roma Tre* A tale of two measurements	**Stefanie Barz** *Stuttgart* Ingredients for photonic quantum computing: entanglement, fusions, and integration
11:00	**Sean Moore** *Lip6, Sorbonne* Secure networks of quantum sensors and quantum state verification at Lip6	**Shaurya Aarav** *INSP, Sorbonne* Correlations in classical and quantum speckles	**Liubov Markovich** *Leiden* Quantum memory assisted observable estimation
12:00	Lunch	Lunch	Lunch
14:00	**Jacob Dunningham** *Sussex* Secure sensing on networks with no (or minimal) entanglement	**Lorenzo Maccone** *Pavia* Time-energy interplay in quantum metrology	**Rafał Demkowicz-Dobrzański** *FUW Warsaw* Quantum Metrology - an almost perfect theory with just a few cracks
15:00	**Joseph Ho/Russell Brooks** *Heriot Watt* Quantum sensor privacy in distributed metrology tasks and resolving multiple parameters of photonic systems	**Matteo Paris** *Milan* (statistical) Complexity of quantum states and operations	**Alexssandre de Oliveira Junior** *DTU* Privacy in continuous-variable distributed quantum sensing
16:00	**Majid Hassani** *Leiden* Many-body k-local ground states as probes for Unitary quantum metrology	**Laurent Labonté** *Côte d'Azur* Towards High-Dimensional Quantum Frequency Correlations Using Fiber-Based Fabry–Perot Resonators.	**Luís Bugalho** *IST, ULisbon & PQI* Spatial Sensing: connecting quantum information to applications
17:00	Coffee & discussion	Coffee & discussion	Close, Coffee & Discussion
18:00	End of day	End of day	End of workshop

Venue: Room 105, first floor, between towers 25 and 26, 4 place Jussieu, F-7005, Paris

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Sean Moore (Lip6, Sorbonne Université)

Wednesday 11th February 11:00-12:00

Secure networks of quantum sensors and quantum state verification at Lip6

Secure networks of quantum sensors are systems where entangled states are distributed over multiple remote nodes through untrusted quantum communication channel to perform a joint metrology task using authenticated classical communication. They aim in general to assure weak privacy, where the parameter of every individual node remains private. In the case of a distributed GHZ state they can assure strong privacy, where only the target function can be estimated. However, experimental implementations must be robust to noise and the states used must be certified in a robust manner. Quantum state verification provides a robust cryptographic method of certifying the distributed state with local measurements. Researchers at Lip6 have developed theoretical tools for the robust verification and privacy bounding of secure networks of quantum sensors and an experimental implementation with four qubit photonic GHZ states. They have also developed further extensions to the theory such as estimation integrity and protocols with anonymous participation.

Jacob Dunningham (University of Sussex)

Wednesday 11th February 14:00-15:00

Secure sensing on networks with no (or minimal) entanglement

Entanglement is a powerful resource for quantum sensing and metrology, but its creation and distribution poses practical challenges for large-scale networks. In this talk I will explore what can be achieved in secure quantum sensing schemes when there is no, or only minimal, entanglement. I will begin by reviewing a simple entanglement-free single-node scenario and will then extend the discussion to networked architectures, showing how hybrid strategies that combine single particles and entangled states can dramatically reduce security overheads while enabling quantum enhanced measurements. I then explore whether enhanced estimation of global functions of parameters is possible without using entanglement at all. Surprisingly, significant gains can be achieved using classical data-analysis techniques—most notably James–Stein–type estimators. This can be improved further with the use of modest quantum resources. These results highlight practical alternatives to fully entangled schemes and point toward scalable, secure quantum sensing networks.

Joseph Ho & Russell Brooks (Heriot Watt University)

Wednesday 11th February 15:00-16:00

Quantum sensor privacy in distributed metrology tasks and resolving multiple parameters of photonic systems

Private parameter estimation (PPE) is a distributed sensing protocol where only aggregate information is accessible, while individual sensor data remains confidential. We implement the PPE protocol by distributing a three-photon Greenberger-Horne-Zeilinger (GHZ) state among three sensors, which is verified using stabilizer measurements to establish privacy and precision bounds for the sensing task. We demonstrate Heisenberg-limited precision scaling of the global parameter while suppressing the metrological information of the local parameters by up to three orders of magnitude, marking a crucial step towards developing advanced quantum-secure-and-private protocols in complex quantum networks. We further investigate the use of resolved measurement schemes for multiparameter estimation and enhanced dynamic range sensing of two-photon systems.

Majid Hassani (Universiteit Leiden)

Wednesday 11th February 16:00-17:00

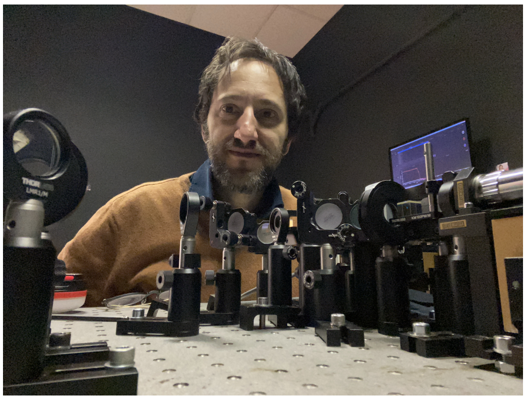
Many-body k-local ground states as probes for Unitary quantum metrology

Multipartite quantum states saturating the Heisenberg limit of sensitivity typically require full-body correlators to be prepared. On the other hand, experimentally practical Hamiltonians often involve few-body correlators only. Here, we study the metrological performances under this constraint, using tools derived from the quantum Fisher information. Our work applies to any encoding generator, also including a dependence on the parameter. We find that typical random symmetric ground states of k-body permutation-invariant Hamiltonians exhibit Heisenberg scaling. Finally, we establish a tradeoff between the Hamiltonian's gap, which quantifies preparation hardness, and the quantum Fisher information of the corresponding ground state.

Marco Barbieri (Università Roma Tre)

Thursday 12th February 10:00-11:00

A tale of two measurements



The goal of quantum metrology is to understand how to make the best usage of resources when carrying out a measurement. It is not hard to conceive scenarios in which this task demands a certain degree of collaboration among partners, which may be connected by sharing quantum states. This talk is devoted to an overview of our recent experiments that have looked at this problem under different angles. We will discuss advantaged and limitations of intervening with non-projective measurements during evolution in underconstrained models. Further, we will add considerations on privacy and security of distributed measurements.

Shaurya Aarav (INSP, Sorbonne Université)

Thursday 12th February 11:00-12:00

Correlations in classical and quantum speckles

When light passes through a scattering medium, it forms a random interference pattern known as speckles. While these patterns may appear noisy, they carry rich information in their correlations. They are particularly valuable where scattering is unavoidable, such as biological tissue in imaging or atmospheric turbulence in free-space communication. In the first part of this talk, I will introduce speckles in the classical regime and show how analyzing their propagation enables 3D imaging of objects hidden behind scattering layers. I will then transition to the quantum regime, exploring two-photon speckles and the novel features that emerge from their inherently high-dimensional structure. Finally, I'll combine the two regimes and discuss how insights from classical speckle analysis can guide wavefront shaping techniques to preserve entanglement between photon pairs going through scattering media.

Lorenzo Maccone (Università di Pavia)

Thursday 12th February 14:00-15:00

Time-energy interplay in quantum metrology

We treat both energy and time as a resource, showing that, in the presence of noise, there is a nontrivial interplay between the average energy and the time devoted to the estimation. Our results are valid for the most general metrological schemes (e.g. adaptive schemes which may involve entanglement with external ancillae or any kind of continuous measurement). We apply recently derived precision bounds for all parameters characterizing the paradigmatic case of a bosonic mode, subject to Lindbladian noise. Based on arXiv:2409.18791.

Matteo Paris (Università degli Studi di Milano)

Thursday 12th February 15:00-16:00

(statistical) Complexity of quantum states and operations

We introduce a quantifier of complexity for continuous-variable states based on the Husimi quasiprobability distribution and discuss its extension to discrete-variable systems. The quantity is built upon the Wehrl entropy, capturing the spread of the distribution, and the Fisher information with respect to location parameters, which captures the opposite behaviour, i.e. localization in phase space. We analyze the basic properties of the quantifier and illustrate its features by evaluating complexity of several families of CV and DV quantum states, also discussing the measure of complexity for quantum operations that may be built from our complexity of states. Finally, we discuss the generalization to a fully quantum measure of complexity based on von Neumann entropy and quantum Fisher information.

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Laurent Labonté (Université Côte-d'Azur)

Thursday 12th February 16:00-17:00

Towards High-Dimensional Quantum Frequency Correlations Using Fiber-Based Fabry–Perot Resonators

High-dimensional quantum states encoded in the frequency degree of freedom constitute a powerful resource for quantum information processing, quantum communications, and distributed quantum sensing. In particular, frequency-bin entanglement offers intrinsic scalability, robustness to transmission losses, and native compatibility with fiber-based networks. While integrated microresonators have enabled impressive progress in this direction, alternative low-loss and plug-and-play platforms remain largely unexplored in the quantum regime. In this work, we investigate the generation and characterization of high-dimensional frequency-correlated photon pairs using a fiber-based Fabry–Perot resonator operated below threshold. Photon pairs are produced via spontaneous four-wave mixing, leading to energy-time entangled twins whose joint quantum state is coherently distributed over multiple frequency-bin modes defined by the cavity free spectral range. This architecture enables the direct encoding of a qudit in the joint frequency state of a photon pair, with a GHz-scale mode spacing compatible with standard telecom components. We present the experimental implementation of the source, including cavity design, spectral properties, and noise analysis, with particular emphasis on the contribution of Raman scattering.

Stefanie Barz (Universität Stuttgart)

Friday 13th February 10:00-11:00

Ingredients for photonic quantum computing: entanglement, fusions, and integration

This talk explores key aspects of photonic quantum systems and their applications in quantum computing. It will cover three aspects: generation of resource states, fusion operations, and scalability via integration. . I will begin by discussing quantum interference and its role in creating resource states for photonic quantum computing. Next, I will examine fusion operations, which form the fundamental building blocks for photonic quantum processors and networks. Finally, I will consider how photonic integration enables scalable architectures, highlighting both the opportunities and challenges in realising larger, more complex quantum systems.

Liubov Markovich (Universiteit Leiden)

Thursday 12th February 11:00-12:00

Quantum memory assisted observable estimation

The estimation of many-qubit observables is an essential task of quantum information processing. The generally applicable approach is to decompose the observables into weighted sums of multi-qubit Pauli strings, i.e., tensor products of single-qubit Pauli matrices, which can readily be measured with low-depth Clifford circuits. The accumulation of shot noise in this approach, however, severely limits the achievable variance for a finite number of measurements. We introduce a novel method, dubbed *coherent Pauli summation* (CPS), that circumvents this limitation by exploiting access to a single-qubit quantum memory in which measurement information can be stored and accumulated. CPS offers a reduction in the required number of measurements for a given variance that scales linearly with the number of Pauli strings in the decomposed observable. Our work demonstrates how a single long-coherence qubit memory can assist the operation of many-qubit quantum devices in a cardinal task.

Rafał Demkowicz-Dobrzański (FUW Warsaw)

Friday 13th February 14:00-15:00

Quantum Metrology - an almost perfect theory with just a few cracks

Recent theoretical developments have rendered quantum metrology a mature field, where some of the most fundamental question have been answered and efficient computational tools developed. We have now a full understanding of quantum metrological potential in case of noisy single parameter estimation models, provided the noise may be assumed to be Markovian. Nevertheless, non-Markovian models remain challenging and efficient universal theoretical tools are still missing. Apart from that, multi-parameter estimation scenarios may pose a challenge even in the Markovian regime, not to mention non-Markovian one. Do not despair, though, some progress is being made. . .

Alexssandre de Oliveira Junior (Danmarks Tekniske Universitet)

Thursday 12th February 15:00-16:00

Quantum memory assisted observable estimation

Can a distributed network of quantum sensors estimate a global parameter while protecting every locally encoded value? In this talk, I answer this question affirmatively by introducing and analysing a protocol for distributed quantum sensing in the continuous-variable regime. We consider a multipartite network in which each node encodes a local phase into a shared entangled Gaussian state. We show that the average phase can be estimated with high precision, exhibiting Heisenberg scaling in the total photon number, while individual phases are inaccessible. Although complete privacy - where all other combinations of phases remain entirely hidden - is unattainable for finite squeezing in multi-party settings, it emerges in the large-squeezing limit. We further investigate the impact of displacements and optical losses, revealing trade-offs between estimation accuracy and privacy. Finally, we benchmark the protocol against other continuous-variable resource states.

Luís Bugalho (IST, ULisbon & PQI)

Friday 13th February 16:00-17:00

Quantum Metrology - an almost perfect theory with just a few cracks

Quantum sensor networks sets a framework for distributed sensing, aimed at retrieving information from spatially separated probes using quantum resources, enhancing precision beyond classical limits. Past works presented a connection between estimating linear functions and entangled states, achieving such estimation with maximum precision. In this work we aim at connecting the usefulness of these sets of states to real-world problems. In what we connote as spatial quantum sensing the goal is, given an underlying field and a set of quantum sensors interrogating the field in a set of positions, to find a linear estimator for some property the field. This property can have multiple forms, be it distinguishing the source of a target signal, or evaluating the field (or a derivative thereof) in an arbitrary position. We find that the estimators that come out as a solution to the problem are such that a non-local entangled strategy provides maximum precision. We start by working under the assumption of polynomial fields, which relates to the interpolation problem, and then generalize for any signal that is modeled via analytical functions, giving rise to any general least-squares estimator. We discuss the effects of the placement of the sensors in the estimation, namely, how to find well defined, construction error-free placements for the sensors. In the case of interpolation we provide concrete examples and proofs in a m-dimensional array of sensors, and discuss necessary and sufficient conditions for the more general cases. We provide clear examples of the possible use-cases and statements, and compare a non-local entangled strategy with the best local strategy for an interpolation problem, showing the benefit in terms of precision in a distributed sensing scenario. This is a key tool for a wide-range of problem in sensing problems, ranging from large-scale such as earth-sized experiments, to local-scale, such has biological experiments. Finally, we apply this to entangled atom gravimeters networks, showing preliminary results which demonstrate potential for high-precision Earth interior modeling.